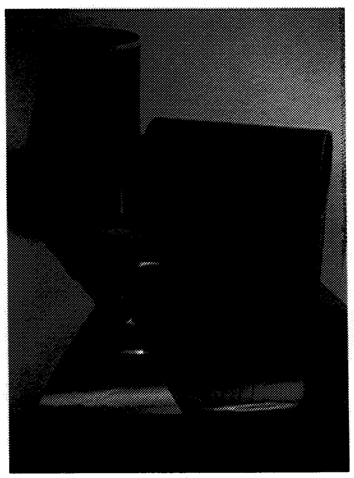


Flexible circuitry is an arrangement of printed wiring that offers certain advantages over other means of interconnecting the components of an electronic system. First applied on military aircraft and missiles, where size, weight and reliability are of primary importance, the circuitry's flexibility allows it to be molded to the shape of a chassis for marked reduction in bulk. Although flex circuits generally cost more than conventional connectors, they nonetheless offer savings in some applications because they are less costly to install. The flexible circuit is also attractive in dynamic applications, those that involve continuous or periodic movement of the circuitry; in such applications, where reliability must be maintained over millions of flexing cycles, flexible circuits have demonstrated excellent performance.

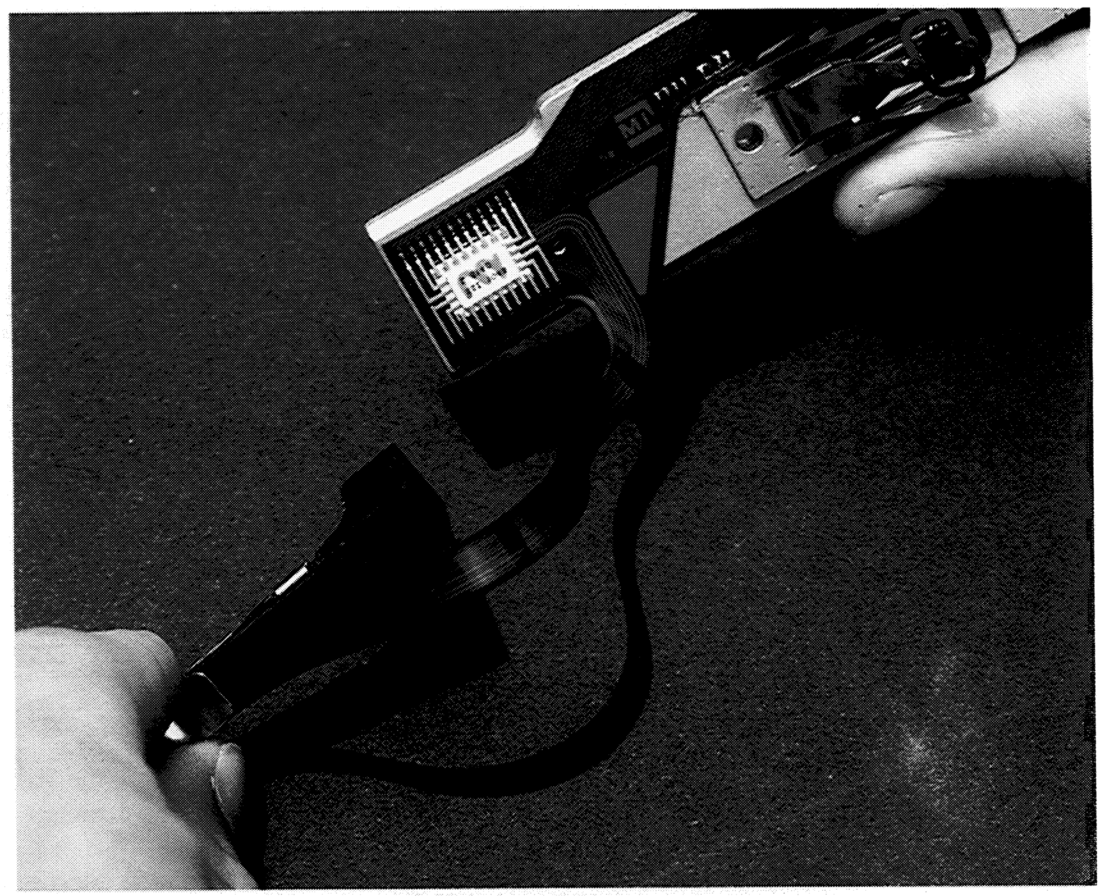
Now being used in a broad range of civil applications as well as in military and space systems, flexible circuits are produced by combining three materials: an insulating plastic film; a metallic conductor, usually copper foil; and an adhesive, one of several types of polymers, to bind the insulator and the conductor into a laminated circuit. The adhesive is important to the overall performance of the circuit and it is selected with care, taking into consideration such factors as bond strength; resistance to temperature during processing and in the operation of the end product; resistance to moisture, which can create "voids" or defects in the bond; insulation resistance; and the flexible lifetime of the printed circuit.

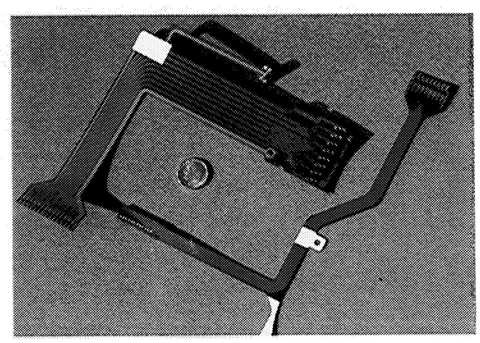
A new type of laminating adhesive has made its appearance in commercial manufacture of flexible electronic circuits. Developed by Langley Research Center, it is a thermoplastic polyimide resin known as LARC-TPI; it is being used to produce laminates, under an exclusive NASA license, by Rogers Corporation's Circuit Materials Division, Chandler, Arizona, one of the nation's largest manufacturers of flexible circuits. NASA has granted a license to Japan's Mitsui Toatsu Chemicals to produce the resin and Mitsui has built a plant for commercial production of the adhesive; NASA is in the process of licensing Rogers Corporation and three other companies to make the resin.

The family of linear polyimides of which LARC-TPI is a member are generally tough, flexible and have excellent mechanical and electrical characteristics over a wide temperature range. Hence, they have been used —and are being considered for broader future use—as structural adhesives for bonding together parts of aircraft, missiles and spacecraft subjected to high temperatures, for example, engine nacelles and cowls, or the friction-heated leading edge of a high speed airplane. The problem with linear polyimides is that they have been difficult to process.

Special requirements for bonding components of a proposed space system led Langley Research Center to undertake development of an advanced structural adhesive by chemically altering the structure of the linear polyimide to improve its overall characteristics and eliminate processing problems. The resulting LARC-TPI has substantially improved processability; it can be processed at lower temperature and it has good moisture resistance, both of which contribute to preventing formation of voids; and it has excellent adherence to a large number of plastics and metals. Although originally developed as a structural adhesive, LARC-TPI was found to have special utility in laminating flex circuits and it has other applications, such as a matrix for fiber reinforced composite materials; for high temperature resistant films, foams and fibers; and as a molding powder for void-free molded parts.

In its initial commercial application by Rogers Corporation's Circuit Materials Division it is being used as the adhesive that binds the insulating film Kapton® to copper foil conductor material in the manufacture of flexible circuits; the photo at left shows a spool of copper foil and a spool of Kapton. In the other photos are representative Rogers Corporation flexible circuits; the coins indicate size. The product line of the Circuit Materials Division spans a broad spectrum that includes flexible circuits for such consumer products as electronic watches, cameras, TV games, calculators and burglar alarms; industrial applications such as display panels, medical instruments, test instrumentation, optical controls and electrostatic copiers; computer jumpers, memories, terminals and printers; aerospace systems such as missiles, transponders, telemetry and avionics; such automotive applications as dashboard clusters, fuel controls, engine controls and pollution controls; and, in communications, CB radios, telephone receivers, telephone switching equipment, pagers and antennas. ▲





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